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Collective behaviour of the interwell excitons in biased GaAs/AlGaAs double quantum wells

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Photoluminescence (PL) and photoluminescence excitation spectra of the interwell excitons of GaAs/AlGaAs double quantum wells (n-i-n structures) with a thin AlAs barrier (four monolayers) have been investigated under applied electrical bias. In the limit of a rather weak excitation power and low enough temperatures interwell excitons are strongly localized on the random potential fluctuations and exhibit in photoluminescence spectra an inhomogeneously broaden line (FWHM of 3–4 meV) related with a laterally fluctuating potential relief. Under resonant photoexcitaion of 1s HH-intrawell excitons by circularly polarized light we have observed a significant narrowing of PL interwell exciton line (down to 1 meV) on excitation power. Simultaneously we have found a superlinear growth of PL intensity and a sharp increase of the circular polarization degree of the corresponding interwell exciton line. Besides of optical orientation of interwell exciton by resonant circularly polarized resonant excitation we have found a sharp increase of the optical dipole moment alignment of the interwell excitons by linearly polarized resonant photoexcitation. All above described phenomena are very sensitive to the temperature and are observed only at $T < 5$ K.

Same behavior of the interwell radiative recombination, — narrowing of the interwell exciton line, its critical behavior on temperature and significant increase of the corresponding radiative decay rate, — we have observed under picosecond laser photoexcitation and by consequent analysis of the time evolution of PL spectra.

Described phenomena are associated with the creation of a collective excitonic phase. Dielectric excitonic nature of this new phase is confirmed by its diamagnetic behavior and by Zeeman splittings in magnetic field parallel to the structure growth direction (Faraday geometry). Space coherence of collective excitonic phase is investigated and discussed.